



Early Journal Content on JSTOR, Free to Anyone in the World

This article is one of nearly 500,000 scholarly works digitized and made freely available to everyone in the world by JSTOR.

Known as the Early Journal Content, this set of works include research articles, news, letters, and other writings published in more than 200 of the oldest leading academic journals. The works date from the mid-seventeenth to the early twentieth centuries.

We encourage people to read and share the Early Journal Content openly and to tell others that this resource exists. People may post this content online or redistribute in any way for non-commercial purposes.

Read more about Early Journal Content at <http://about.jstor.org/participate-jstor/individuals/early-journal-content>.

JSTOR is a digital library of academic journals, books, and primary source objects. JSTOR helps people discover, use, and build upon a wide range of content through a powerful research and teaching platform, and preserves this content for future generations. JSTOR is part of ITHAKA, a not-for-profit organization that also includes Ithaka S+R and Portico. For more information about JSTOR, please contact support@jstor.org.

REVIEWS

Secondary Enrichment of Ore Deposits. By S. F. EMMONS. Trans. American Inst. Min. Eng., Vol. XXX, 40 pp., 1900.

Enrichment of Gold and Silver Veins. By WALTER HARVEY WEED. Trans. Amer. Inst. Min. Eng., Vol. XXX, 25 pp., 1900.

In the exploitation of ore bodies it has been found that many deposits decrease in richness as depth increases. The explanations have been various. That the phenomenon is a far more general one than was once supposed, has only recently been recognized in its full significance. It may be expected to be very frequently met with, now that its real character has been found out, by all students of ore deposition.

It is now a well-known fact that as geological formations, ore-bodies as a rule are to be regarded as deposits originating very near the surface of the earth's crust; or, to be more precise, in the thin outer belt of the zone of fracture of the lithosphere. The unusual richness of many ore deposits at very shallow depths has come to be considered as due to local enrichment, often long after the first concentration has taken place.

From the viewpoint of origin, diminution of richness with depth is not, then, to be ascribed to actual depreciation in the original grade of the ore. The real status of the case is that the deposition of ore has, in the upper belt, undergone a greater or less augmentation in metallic content since the body was first formed.

Among those who have given the subject of ore genesis most attention, and especially among those who have approached the subject from the geological side, the rival theories of ascending solutions, descending solutions, and laterally moving solutions, no longer find countenance as distinct processes. Ore deposition may take place through all three means, which may have equal importance. After an ore deposit has once formed under special geological conditions, the secondary enrichment which it may undergo is believed to take place largely under the influence of the descending solutions.

In the exploitation of the ore-bodies, it all goes to show how vitally important is a full consideration of the geological structures presented at the time of the first concentration, and as subsequently assumed.

The keynote of Mr. Emmons' paper is given in one of the opening paragraphs, when he says that "admitting fully the general truth of the statement that the descending surface waters exert an oxidizing action, and hence that oxidation products within the reach of surface waters are the result of the alteration by the latter, I have been led to believe, by observations now extending over a considerable number of years, that under favorable conditions the oxidation products may be changed back again into sulphides and redeposited as such, thus producing what may be called a sulphide enrichment of the original deposits. . . . Being rather a searcher after facts than a theorist, I am not deterred from accepting what may appear to me the correct reading of observed facts, because it seems to contradict generally accepted theories."

After briefly discussing the circulating waters of surface origin, the groundwater level, the deposition of oxides below water-level, and the deposition of sulphides, the author goes on to give an account of many cases of secondary enrichment which his wide experience has brought to notice. This account occupies the greater part of the paper. The three propositions following are believed to be substantiated by the geological evidence adduced:

1. That descending waters not only cause migrations, or transference and reconcentration, of the alteration products of the original vein-materials in oxidized form, producing in one place an enrichment, and in another possibly an impoverishment of the original deposit, but that in their further downward course the oxidized forms are frequently reduced and redeposited as sulphides, thereby producing a sulphide enrichment of the original vein-materials.

2. That this secondary enrichment of sulphides is not necessarily a reduction in the presence of organic matter, but is frequent where no organic matter can be supposed to be present. It occurs mainly in contact with the original sulphides of the deposits, and is, presumably, a result of chemical reaction between these sulphides and the materials brought down in solution by the descending waters.

3. That while this redistribution of sulphides in many cases appears to commence at or near the groundwater-level, it does not appear to

have a necessary connection with that level, and may under favorable conditions extend below that level for a distance as yet undetermined, the most important favoring conditions appearing to be recent or post-mineral fractures, which have admitted a relatively free and uninterrupted descent of these waters.

In conclusion, students are cautioned against making the inference too sweeping. "Until a much larger number of ore deposits have been studied with a definite purpose of determining how far they have been subjected to secondary enrichment, it does not seem safe to draw any far-reaching conclusions from the observations and suggestions noted above. It has long been recognized that the superficial alteration of ore deposits has often produced a very considerable modification of the original constitution of the deposit, and its alteration has so frequently been in the nature of an enrichment in the more valuable metals relatively to the original tenor of the ores, that it has given rise to the very hasty decision that all ore-deposits necessarily become poorer in depth, which is almost as unjustifiable as the old assumption by the miner, that the nearer he got to the source of his ore in the unknown deposits, the richer it would become.

"The fact that ores under some conditions may be removed and redeposited as sulphides, even below groundwater-level, opens a wide field of possibility in accounting for the unusually rich bodies of ore that are in some mines found in the middle levels, and have been fruitlessly sought for at greater depth. In many cases these have undoubtedly resulted from a concentration of material leached down from the upper portions of the deposit as they have been worn down and carried away by denudation. Especially in the case of large bodies of pyritous ore carrying small proportions of more valuable metals, is a concentration of those metals by downward percolating solution to be looked for. It is, however, not yet safe to say that all rich bonanzas in vein deposits have necessarily been formed in this way."

The paper by Mr. Weed gives a brief statement of the theory enunciated in a former contribution. The principles are applied more particularly to the deposits of the precious metals, with special emphasis laid upon the dependence of such enrichments upon the presence of iron sulphide in the primary ore, and upon the structural features which control the circulation of the enriching solutions below groundwater-level. The discussion is largely of Montana deposits, which the author has been engaged in studying for several years past. Regarding

the theoretical chemical changes, those taking place in each of the several zones are considered in detail.

Leaching out of the metals from the portion of the vein lying above groundwater-level is considered as the main source of the enriching materials. The alteration at the surface leaves the iron as a gossan, while the waters carrying the gold, silver, copper, and other metals in solution trickle downward through the partially altered ores into cracks and water-courses which penetrate the ore-body below the water-level. The first of the process is, therefore, the leaching of the lean ores which occurs in the superficial alteration of the vein. In weathering, the sulphides oxidize according to their relative affinity for oxygen and inversely as their affinity for sulphur. It is concluded from the evidence that ore-bodies lacking in iron pyrite will not show enrichment, thus explaining the absence of any such phenomena in the pure silver-lead bodies of the Coeur d'Alene district and elsewhere.

The observations of the author on the effects of physiographic and climatic changes, and on the changes of water-level, are of exceptional significance: "Active degradation favors the accumulation of enrichment, while prolonged degradation of a region, resulting from physiographic revolutions, may result in successive migrations of material and the accumulation in a relatively shallow zone of the metals derived from many hundreds, and possibly thousands, of feet of the vein worn away in the degradation of the land. Climatic conditions, rainfall or aridity, warmth and rapid alteration of vein fractures, are agents affecting surface weathering, and hence, also, enrichment.

"Active degradation of a region, that is, rapid weathering, favors enrichment by the quickness with which it removes the upper already leached part of the vein, so that a larger amount of the vein-matter is lixiviated in a given time than would result from the slower wasting of the land. Such enrichments are favored by high latitudes. Moreover, the mountainous regions are those in which secondary fractures are most apt to be found.

"Prolonged degradation is favorable for a similar reason, since time is a factor in enrichment and changes in elevation, etc., affect the rate and the progress of decay of the vein; while the crustal movements accompanying the physiographic changes favor fracturing of the earlier deposit, increasing facility of leaching and place for deposition. If a region passes through several cycles of erosion and elevation, it is evident that their result is likely to be a succession of enrichments in

which not only the original ore is leached, but the earlier enrichment deposits migrate downward. At Butte, Mont., the region has passed through several very pronounced changes in elevation since the formation of veins in Tertiary time. In early Tertiary time the present topography of the region was blocked out, and mountain ranges and deep valleys carved. This was succeeded by earth movements by which the streams became clogged or the valleys dammed, forming lakes; while volcanoes broke out at numerous places and showered ashes and scoria over the region. The valleys were silted up or in part filled with volcanic débris before crustal movements drained the valleys and altered the divides. More recent movement, possibly still continuing, is marked by faults and a reversing of the stream courses. The old valley at Butte is filled by hundreds of feet of débris, and a mountain wall 2500 feet high marks a north and south fault-line. These changes all caused a migration of water-level facilitating the processes of weathering and enrichment, and the great bodies of rich copper ores of the region are believed to be in part due to this cause."

CHARLES R. KEYES.

Enrichment of Mineral Veins by Later Metallic Sulphides. By
WALTER HARVEY WEED. Bull. Geol. Soc. Am. Vol. XI,
pp. 179-206, 1900.

The author calls attention to the occurrence of localized masses of exceptionally rich ore in mines of copper, silver and zinc, which he undertakes to explain as the result of enrichment by processes subsequent to the deposition of the lower grade ore. The paper attempts to show that these richer bodies of sulphide ore are formed by the redeposition of material leached from the vein, generally by superficial waters, and to show the chemical and mineralogical changes involved, as well as the physical conditions under which redeposition took place. The ores in question are chiefly the high grade sulphides.

He describes three zones; that of oxidation, that of sulphide enrichment, and that of primary sulphides, and refers to the writings of DeLaunay, Prosepnny, Penrose, Emmons and Kemp in this connection. In discussing the chemical and mineralogical changes supposed to take place, he compares unaltered and altered ore and drainage waters observed by himself and cites freely from the literature of the subject, concluding that together they show that the original ore is